Size Effect in One-dimensional $NbSe_3$ and $NbSe_2$

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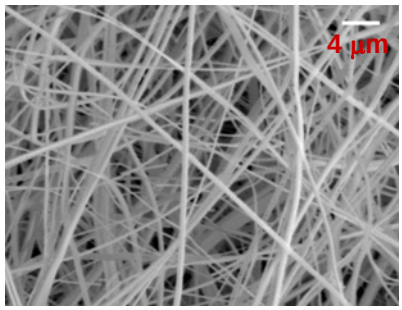
Motivation

- Niobium triselenide ($NbSe_3$): a model system for investigating charge-density-waves (CDWs).
- Niobium diselenide ($NbSe_2$): a conventional superconductor with rich vortex physics.
- Exploring phenomena and physics in pristine crystals at the mesoscopic scale.
- Developing new approaches to synthesize one dimensional (1D) crystals.

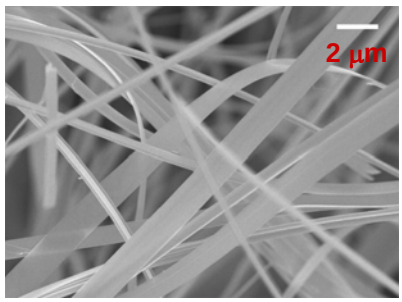
Major Accomplishments

- $NbSe_3$ nanowires and nanoribbons synthesized through direct reaction of Nb and Se powders
- $NbSe_2$ nanowires and nanoribbons converted from $NbSe_3$ precursors.
- Size effects observed in both CDW and superconducting (SC) systems.

$NbSe_3$

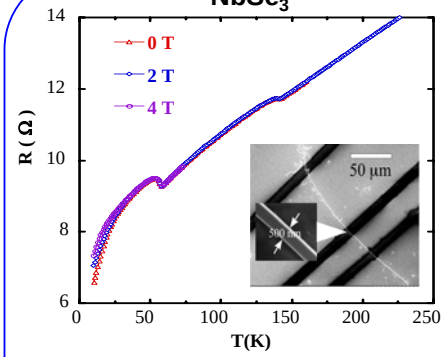


- Wires of 20 ~ 700 nm in diameter

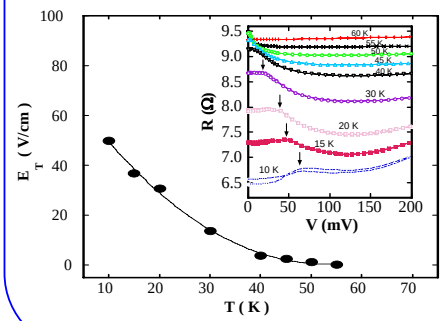


- Ribbons of 10 ~ 500 nm thick

$NbSe_3$

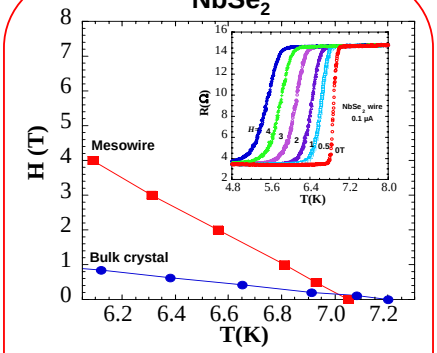


- Smaller residual resistance ratio
- Smaller resistance bumps

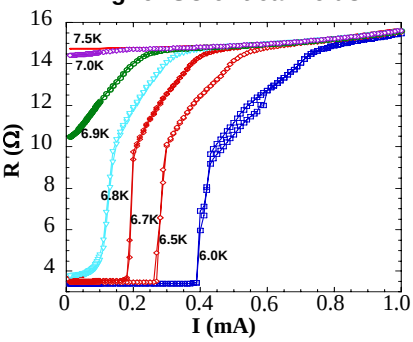


- Larger CDW depinning field E_T

$NbSe_2$



- Higher SC critical fields



- Resistance steps at high currents

Future Directions

$NbSe_3$

- CDW phase transitions at various geometries and sizes
- CDW pinning mechanisms at the nanoscale

$NbSe_2$

- Phase diagrams of normal~superconducting transitions of nanowires with various cross-section sizes
- Thermal and quantum phase slips
- Mechanisms for current-induced breakdown of superconductivity
- Dynamics of a few vortex rows in nanoribbons

"few vortex rows" superconductor

Y. S. Hor et al., Applied Physics Letters 87, 142506 (2005)

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